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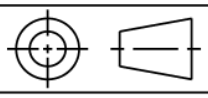
FRACTIONS DECIMALS ANGLES

THIRD ANGLE PROJECTION



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MATERIAL

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JOHN F. KENNEDY SPACE CENTER, NASA
KENNEDY SPACE CENTER, FLORIDA

FLEX HOSE SPECIFICATION, CRYOGENIC, VJ, LO2, UMBILICAL, UPPER STAGE

SIZE	CAGE CODE	DWG NO	REV
A	22264	890M3100006	–

SCALE	UNIT WEIGHT	SHEET	OF
None	—	1	23

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

g	gravity, force of
GO2	Gaseous Oxygen
GHe	Gaseous Helium
GN2	Gaseous Nitrogen
GSE	Ground Support Equipment
Hg	Mercury
KSC	John F. Kennedy Space Center
MAWP	Maximum Allowable Working Pressure
LO2	Liquid Oxygen
LN2	Liquid Nitrogen
KSC	John F. Kennedy Space Center
MLE	Mobile Launcher Element
MLI	Mulit Layer Insulation
NASA	National Aeronautics and Space Administration
NDE	Non-Destructive Evaluation
psig	Pounds per square inch gauge
sccs	Standard cubic centimeters per second
sec	Second
TUUA	Tilt Up Umbilical Arm
VC	Visually Clean

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1. SCOPE

This document specifies the minimum technical requirements for the design, fabrication, and qualification of vacuum jacketed flex hoses that will transport cryogenic propellant, liquid oxygen (LO2), as part of Kennedy Space Center (KSC) Ground Support Equipment (GSE) of the Constellation Program. The flexible hose assemblies will be located at the Tilt Up Umbilical Arms (TUUA).

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. The latest revision applies unless a specific revision is indicated. However, when this document is used for procurement, including solicitations, or is added to an existing contract, the specific revision levels, amendments, and approval dates of said documents shall be specified in an attachment to the Solicitation/Statement of Work/Contract.

In case of conflict between referenced document and this specification, this specification shall take precedence

2.1 Governmental

National Aeronautics and Space Administration (NASA)

NASA-SPEC-5004	Welding of Aerospace Ground Support Equipment and Related Nonconventional Facilities
NASA-STD-5005	Standard for the Design and Fabrication of GSE

NASA/Kennedy Space Center

KSC-C-123	Surface Cleanliness of Fluid Systems, Specification For
KSC-STD-E-0015	Marking of Ground Support Equipment, Standard For
KSC-STD-G-0003	Qualification of Launch Support and Facility Components Standard For
MSFC 20M02540	Assessment of Flexible Lines For Flow Induced Vibration

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Drawings

79K14672	Vacuum Pump out ports
242F1800008	Isometric Drawing LO2 System, Mobile Launcher

STANDARDS

American Society of Nondestructive Testing (ASNT)

ASNT-TC-1A	Recommended Practice, Personnel Qualification and Certification in Nondestructive Testing

Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions should be obtained from the procuring activity or as directed by the Contracting Officer.

2.2 Non-Governmental

The American Society of Mechanical Engineers

ASME B31.3	Process Piping
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory-Made Wrought Buttwelding Fittings

American Society of Testing and Materials

ASTM A182	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service

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ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A380	Practice for Cleaning, Descaling, and Passivation of Stainless Steel parts, Equipment, and Systems
ASTM A580	Standard Specification for Stainless Steel Wire
ASTM A967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
ASTM B575	Standard Specification for Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip

ISO

ISO 10380	Pipework - Corrugated Metal Hoses and Hose Assemblies

International Code Council

IBC	International Building Code

3. REQUIREMENTS

3.1 Definition

The assemblies are vacuum jacketed flex hoses used to deliver cryogenic propellant (LO2 and GO2) as part of the ground support equipment (GSE) on the Constellation program.

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3.2 Characteristics

3.2.1 Performance Characteristics

3.2.1.1 The service shall be for liquid oxygen (LO2), gaseous oxygen (GO2), and/or gaseous nitrogen (GN2) as designated in Table 1.

3.2.1.2 The design temperatures for all flex hose assemblies shall be +158 degrees F to -297 degrees F.

3.2.1.3 The design pressure for the inner hose of each hose assembly shall be as specified in Table 1 and 0 psia (full vacuum) in the annular space.

3.2.1.4 The design pressures for the outer vacuum jacketing shall be 35 psig internal pressure, and/or 20 psig (above ambient) external pressure and 0 psia (full vacuum) in the annular space.

3.2.1.5 The flex hoses assemblies shall be capable of the flow rates specified in Table 1Error! Reference source not found..

3.2.1.6 The flex hose assemblies shall be capable of bi-directional flow.

3.2.1.7 All flex hose components and spacers shall be designed to withstand a minimum of a three (3) g transportation loads upwards, downwards and to the side and meet International Building Code for Zone 4 seismic requirements with inner hose filled with process fluid.

3.2.1.8 The maximum heat leak for the flex hose from ambient to LO2 cryogenic conditions shall be:

Nominal Size (in)	Btu/hr/ft
0.75 x 2	1.19
1.5 x 3	1.71
4 x 6	3.03
6 x 8	4.10

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Table 1 – TUUA Flex Hoses Design Parameters

Reference Designator	Description	Fluid	Nominal Size (in)	Max Flow Rate (lbm/sec)	MAWP (psig)	Clean Leve
LO2 DA	TUUA LO2 Drain Assist Forward	LO2/GO2/GN2	0.75 non-VJ	TBD	205	300A
LO2 DA	TUUA LO2 Drain Assist Aft	LO2/GO2/GN2	0.75 non-VJ	TBD	205	300A
G3	TUUA LO2 Fill/Drain Forward	LO2/GO2/GN2	4x6	91	205	300A
G3	TUUA LO2 Fill/Drain Aft	LO2/GO2/GN2	4x6	91	205	300A
G16B	TUUA LO2 High Point Bleed Forward	LO2/GO2/GN2	0.5 non-VJ	TBD	205	1000A
G16B	TUUA LO2 High Point Bleed Aft	LO2/GO2/GN2	0.5 non-VJ	TBD	205	1000A

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3.2.2 Physical Characteristics

3.2.2.1 Liquid and gaseous oxygen systems shall use materials that are selected in accordance with NASA-STD-5005. This includes materials inside the vacuum annulus.

3.2.2.2 Reference isometric drawing 242F1800008 for geometry of flex hoses.

3.2.2.3 The inner line shall be closed pitch annular convolution using 316/316L (dual grade) stainless steel.

3.2.2.4 Any inner line hard assemblies shall be ASTM A240 316/316L (dual grade) stainless steel.

3.2.2.5 Any inner line hard pipes shall be ASTM A312 316/316L (dual grade) stainless steel.

3.2.2.6 Socket weld joints shall not be used.

3.2.2.7 The inner line convolutions shall be covered with braided wire reinforcement per ASTM A580 316/316L (dual grade) stainless steel.

3.2.2.8 Alternative inner line material may be used for high pressure hoses by approval of NASA.

3.2.2.9 The outer vacuum jacket shall be closed pitch annular convolution using ASTM B575 N06022 (Hastelloy C22).

3.2.2.10 Any outer line hard assemblies shall be ASTM A240 316/316L (dual grade) stainless steel.

3.2.2.11 Any outer line hard pipes shall be ASTM A312 316/316L (dual grade) stainless steel.

3.2.2.12 The outer line convolutions shall be covered with braided wire reinforcement using N06022 (Hastelloy C22) or N10276 (Hastelloy C276).

3.2.2.13 The inner line shall be wrapped with a multi-layer insulation (MLI) system consisting of alternating layers of aluminum foil and fiberglass paper.

3.2.2.14 The inner hose and pipe shall be supported with spacers that center it within the outer jacket and are designed to minimize heat leak. Spacers shall allow for motion of the convolutes. Spacers shall not be located within 3/4" of a circumferential hose weld.

3.2.2.15 Each vacuum jacket annulus shall be equipped with a chemical gettering system consisting of desiccant, molecular sieve, and hydrogen converter.

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3.2.2.16 Each section of vacuum jacketed hose shall be equipped with a vacuum valve assembly in accordance with 79K14672.

3.2.2.17 Stub-out for vacuum valve assembly attachment shall be 1" NPS and shall be located and oriented as shown on isometric drawings. Relocation shall only be by approval of NASA

3.2.2.18 When bayonet connections are specified on the isometric drawing they shall be close-tolerance design bayonets with B16.5 flanges.

3.2.2.19 Flanges shall be per B16.5 and shall be ASTM A182 F316/F316L (dual graded) stainless steel. Flange styles and pressure classes are as indicated on isometric drawings. All serrations on raised face flanges shall be concentric.

3.2.2.20 Line lengths are from flange face to flange face.

3.2.2.21 Coat all exterior surfaces of stainless steel jacket using STEEL-IT #4210 epoxy primer and STEEL-IT #4907 epoxy finish per manufacturers preparation and application instructions. (Stainless Steel Coatings, Inc., 835 Sterling Road, P.O. Box 1145, South Lancaster, MA 01561) Hastelloy bellows and braid shall not be coated.

3.2.2.22 Coating shall occur after segment pressure / leak / acceptance testing and before final segment marking / labels.

3.2.3 Reliability

3.2.3.1 The flex hose assemblies shall have a minimum 20 year service life under the conditions specified herein.

3.2.3.2 The flex hose assemblies shall have a minimum 8000 mechanical cycles.

The flex hose assemblies shall have a thermal cycle life of a minimum 7000 cycles in accordance with B31.3.

3.2.4 Sustainability

N/A

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3.2.5 Environmental Conditions

3.2.5.1 Vacuum jacketed flex hose parts exposed to the atmosphere shall be made of corrosion resistant materials to be corrosion resistant to saltwater spray.

3.2.6 Transportability

N/A

3.3 Design and Construction

3.3.1 Design

3.3.1.1 All flex hose assembly components shall be designed , fabricated, examined, and tested as normal fluid service with severe cyclic conditions in accordance with ASME B31.3.

3.3.1.2 All structural attachments shall be 2 times to yield stress and 3 times to ultimate stress.

3.3.1.3 The braid burst pressure shall be 4 times the design pressure for each hose assembly.

3.3.1.4 Inner pipe weld design shall accommodate 100% radiography.

3.3.1.5 All flex hose designs shall have a stress and flexibility analysis based on the load combinations per Table 2.

3.3.1.6 The inner hose convolute dimensions shall be designed to minimize flow induced vibration fatigue effects based on flow rates per Table 1. Analysis based on MSFC 20M02540 or equivalent shall be performed for each hose assembly.

3.3.1.7 The inner hose convolute section manufactured length is the live length plus compression length.

3.3.1.8 Compression length shall be designed to include braid tension required for full engagement of convolutes with vacuum in outer annulus, inner hose at minimum design temperature, and 0 psig in inner hose.

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Table 2 - Loading Conditions

Load Case	Sustained Loads				Thermal Range Stress: Internal & External Pipe	Occasional Loads							Comments &/or B31.3 Allowable Applicable Equations
	Pressure (Internal & external pipe)	Deadload (see note 9)	Liveload (Fluid Weight)	Operation Wind Load (54.1 mph)		Hurricane (Wind speed 130 mph)	Crawler Induced Vibration	Launch Induced Vibration	Flow Induced Vibration	Seismic	Launch Blast Pressure	TUAA / flexhose Motion	
ASME B31.3 Requirements													
Section 304 to calculate allowable thickness for pipe, elbows and fittings due to **pressure**	X												Refer to section 304 for applicable formulas
Section 302.3.5 c - Longitudinal Stresses due to **Sustained Loads** - S_L *(See note 1)*	X	X	X	X									$S_L < 1.0\ S_hW$
Section 302.3.5 d - Allowable **Displacement Stress Range** (S_A)					X								$S_A = f\ [1.25S_C + 0.25S_h]$ *See note 3*
Section 302.3.6 - **Occasional Load Stress (longitudinal)**													$S_L < 1.33\ S_hW$
Case 1		X				X							No Fluid
Case 2	X	X	X	X						X			Fluid in pipe
Case 3	X	X	X	X				X			X	X	*See note 7*
Case 4		X		X			X						*See note 7*
Case 5	X	X	X	X					X				*See note 7*
Case 6	X	X	X	X								X	For piping connected to flexhose

Notes:
1. The load due to any wind during launch is assumed at 54.1 mph
2. Nozzle loads if applicable and restraint loads will be calculated in the flexibility analysis
3. The Thermal Expansion formula is based on Equation 1a in Section 302.3.5 d. However the code allows the alllowable to increase by the difference of S_h and Sustained Stress S_L, refer to
4. The SIF for fittings is included in the flexibility analysis
5. Other calculations per B31.3 such as Bolt Loads etc. will be calculated based on forces and moments from the flexibility analysis
6. "**X**" denotes load cases to be included in calculations to meet ANSI B31.3 requirements
7. The seismic loads are based on NASA Vandenburg, California, based on discussion this load will encompass the other described occasional loads as this is conservative approach
8. For the Oxygen System the following is considered: Pressure 300 PSIG and Temperature range -321 ^oF to 158^oF
9. The deadload includes piping system weights, which includes (but not limited to) the following: pipe, valves, flanges, fittings etc.
10. The effect of waterhammer is currently not considered as the design includes valve timing control and/or operational mitigation, and therfore the forces will be minimal
11. Hydrostatic pressure and liveload (fluid) will be included as a loading condition.

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3.3.2 Construction

3.3.2.1 All welding shall be performed by qualified welders per weld procedure specifications for each weld in accordance with NASA-SPEC-5004 and ASME B31.3. Weld traceability maps of welder and procedure number at each joint are required for each flex hose.

3.3.2.2 All welding inspections shall be performed by certified weld inspectors in accordance with NASA-SPEC-5004 and ASNT-TC-1A.

3.3.2.3 All welds shall be full penetration welds for severe cyclic conditions in accordance with NASA-SPEC-5004 and ASME B31.3 Chapter V. Backing rings are not permitted.

3.3.2.4 All welds shall meet the requirements for low temperature toughness as per ASME B31.3, paragraph 323.2.2.

3.3.2.5 Attachments to the vacuum jacket shall be made using ASTM A240 316/316L (dual grade) with a full-seal weld to prevent moisture intrusion.

3.3.2.6 All welds shall be 100% visually examined by certified welding inspector per ASME B31.3.

3.3.2.7 All longitudinal seam welds shall be 100% radiographed. Convoluted segments shall be radiographed prior to forming.

3.3.2.8 All inner pipe welds shall be 100% radiograph examined per NASA-SPEC-5004 and ASME B31.3. Do not perform dye penetrant inspection on any weld in the vacuum annulus.

3.3.2.9 All outer jacket welds shall be 100% dye penetrant examined per NASA-SPEC-5004.

3.3.2.10 Weld heat affected areas shall be passivated per ASTM A380. Do not passivate welds that are in the vacuum annulus.

3.3.2.11 Pull braids tight to ensure contact with all convolutes after bellows compression and prior to welding braid in ferrule.

3.3.2.12 The inner surfaces of all flex hose assemblies and components shall be cleaned to levels as specified in Table 1. All cleaning processes and cleanliness level inspections shall be as specified in KSC-C-123.

3.3.2.13 Detail cleaning procedures must be submitted for NASA engineering approval prior to start of cleaning operations.

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3.3.2.14 All work on vacuum jacketed lines which exposes the annular area between the inner and outer line shall be performed in a controlled environment which will minimize the exposure to moist air, oil, grease or other contaminants. A dry GN2 purge shall be maintained whenever possible, after annulus closure. The annulus area of the vacuum jacketed lines shall be maintained clean at all times. Application of tape, grease pencil, and chalk marks shall not be used. Exposed surface areas shall be thoroughly degreased before the annulus is closed.

3.3.3 Electromagnetic Interference

N/A

3.3.4 Name Plates and Product Marking

The flex hose shall be permanently and legibly marked for identification on an outer surface, as per KSC-STD-E-0015; including as a minimum:

- manufacturing vendor's name
- part or model number
- fabrication date
- hydrostatic/pneumatic test date
- pressure rating
- serial number (if applicable)
- size
- static and dynamic minimum bend radius
- KSC drawing number (if any).

3.3.5 Workmanship

Hardware shall be fabricated and finished so appearance, fit, and adherence to specified dimensions and tolerances are observed and in a manner that ensures reliable operations in accordance with the requirements specified herein. Particular attention shall be given to the neatness and thoroughness of constructions and to the freedom of parts from burrs and sharp edges that might damage associated equipment or cause injury to personnel. Any item exceeding the acceptance criteria shall be repaired or replaced and reexamined by the same acceptance criteria as required for the original work.

3.3.6 Interchangeability

Hardware assemblies, components, and parts with the same part number shall be physically and functionally interchangeable

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3.3.7 Safety

N/A

3.3.8 Human-Factors Engineering

GSE design shall ensure that human factors principles are incorporated for accessibility, maintainability, and safety in accordance with the design criteria specified in MIL-STD-1472.

3.3.9 Security

N/A

3.3.10 Government-Furnished Property

N/A

3.4 Logistics

N/A

3.5 Personnel and Training

N/A

3.6 Major-Component Characteristics

N/A

3.7 Precedence

In case of conflict between referenced document and this specification, this specification shall take precedence. Isometric drawing 242F1800008 shall take precedence over individual flex hose drawings.

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3.8 First Article Qualification Testing

Each flexible hose assembly described in this specification shall have a first article fabricated and acceptance tested. First article qualification tests shall then be performed to verify compliance with the requirements of this specification for the following key parameters before fabrication and verification testing of final products begin. Failure to meet any of the requirements of this specification will be cause for rejection of the final product. Test articles may be qualified by one of the following methods detailed in KSC-STD-G-0003 paragraph 4: First article qualification by testing; by similarity; by prior acceptance; by usage and analysis; and qualification by higher level assembly and testing with NASA approval.

3.8.1 Cycle Life - First article qualification testing – A minimum of 8000 mechanical cycles per ISO 10380 Section 5.4, Type 1.

3.8.2 Hydrostatic Bursting test – A First article qualification test sample shall be incrementally pressurized until visible leakage or rupture occurs. Failure shall occur only in the body of the hose and braid and not in their connections.

3.8.3 Cryostat test – A First article qualification test sample of each size and rating shall be cooled to LN2 temperature. After cool down incrementally pressurized to design pressure and back to ambient then warmed to ambient. This shall be performed 10 times.

3.8.4 Force Deflection Test – Determine the spring rate axially and in bending for one complete convolution experimentally. The experimental value obtained will be used to perform the final assessment of the flexible assemblies for Flow Induced Vibration per 20M02540

3.8.5 Stiffness Data Testing –field testing of analysis data submitted at 45% design review of the total force and component forces required to bend the flex hose in the configurations to be provided by NASA.

3.9 Samples

N/A

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4. VERIFICATION

4.1 Responsibility for Inspection

Unless otherwise specified in the contract or order, the supplier shall be responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may use his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.2 Special Tests and Inspections

4.2.1 Flow Testing – Flow test using water for a minimum of 15 minutes at specified flow rates per Table 1 for each hose assembly. Flow test shall be accomplished prior to cleaning hose assemblies.

4.2.1.1 Test shall be performed with hose curved 90 degrees at dynamic bend radius.

4.2.1.2 No permanent deformation or damage shall result from the flow testing.

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4.3 Verification Inspections

The testing in sections 4.3.3 to 4.3.6 shall be performed sequentially. The vacuum annulus shall be evacuated to a minimum of 10 microns of Hg prior to starting this testing.

4.3.1 Required Testing Chronology

The testing in sections 4.3.2 to 4.3.6 shall be performed sequentially after.

4.3.2 Vacuum Retention Test

4.3.2.1 Each section of the vacuum jacketed flex hose outer vacuum jacket shall be evacuated to a minimum of 10 micrometers of Hg pressure.

4.3.2.2 The vacuum level with in each section of the outer vacuum jacket shall be measured and recorded every twenty-four (24) hours for a period of at least seven (7) days.

4.3.2.2.1 The final pressure at the end of the test period within each section of the vacuum jacket must stabilize at or below 50 microns of Hg pressure to be acceptable.

4.3.3 Pressure/Leak Testing

4.3.3.1 The leak pressure test shall be conducted via hydrostatic testing at a minimum of 150% of the design pressure, or be conducted via pneumatic testing at a minimum of 110% of the design pressure.

4.3.3.2 The pressure shall be maintained for a minimum of 5 minutes. The vacuum readings shall be recorded before, during and after the pressure testing. The vacuum jacketed flex hose undergoing test shall exhibit no leakage while undergoing leak testing and show no permanent deformation or damage as result of the leak testing.

4.3.3.3 Leak testing shall be performed at ambient temperature.

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4.3.4 Cold Shock

4.3.4.1 The flex hose assembly shall undergo cold shock testing after the leak testing is completed.

4.3.4.2 The completed vacuum jacketed flex hose will have the vacuum annulus evacuated to a minimum of 10 microns of Hg pressure.

4.3.4.3 The assembly shall be cold shocked with LN2 by tilting the line at least 15 degrees and introducing the LN2 into the assembly at the low end, allowing the boil off gas to vent from the high end. The chilldown and tilting of the assembly shall continue until a steady stream of LN2 is forced out the high end. The LN2 supply shall then be maintained, allowing the assembly to cold-soak for 1 hour.

4.3.4.4 The vacuum readings shall be recorded before, during, and after the cold shock test. The vacuum reading after the cold-shock test shall be taken when the assembly returns to ambient temperature. Post cold shock vacuum reading shall be less than 50 microns of Hg pressure.

4.3.5 Mass Spectrometer Leak Testing

4.3.5.1 The flex hose shall undergo leak testing after the cold shock testing is completed and prior to the application of any coatings on the outer jacket.

4.3.5.2 The vacuum jacket annulus shall be evacuated to a minimum of 10 microns of Hg pressure.

4.3.5.3 No GHe leakage shall be detected with a Helium Mass Spectrometer Leak Detector set to a minimum sensitivity of 1x10-9 sccs.

4.3.5.4 The test shall be accomplished with the inner line pressurized to MAWP with 100% GHe.

4.3.5.5 The outer jacket shall be tested with all jacket welds surrounded by a 100% GHe atmosphere.

4.3.6 Dimensional Verification

4.3.6.1 Flex hose assemblies shall be dimensionally verified to be in accordance with fabrication drawings prior to packaging for shipment.

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4.3.7 Responsibility For Verification / Inspection

4.3.7.1 The vendor shall be responsible for the performance of all verification (analysis, test, demo or inspection) requirements as specified herein. Except as otherwise specified, the vendor may use his own facilities or any commercial laboratory acceptable to NASA. NASA reserves the right to witness or perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.3.7.2 The Vendor shall formulate acceptance test procedures for all components and will provide the facility and instrumentation to perform all relevant tests to ensure compliance with this specification. The acceptance test procedures shall include but not be limited to all of the testing procedures specifically outlined in this document.

4.3.7.3 All items purchased or manufactured by a subcontractor used in the Vendor's work shall be clearly identified and tabulated.

4.3.7.4 All material and components shall be traceable to original vendor via material certification records.

4.3.7.5 NASA reserves the right to have access to the Vendor's facility at any time during the design, fabrication and code testing. NASA shall have the right to witness any manufacturing or testing procedures upon request. When requested, the Vendor shall provide a minimum of 7 days notice in advance of any test date to allow for NASA (or its designated contractor representative) to make the necessary travel arrangements.

4.3.7.6 Review of analysis data and procedures by NASA shall not release the Vendor from its responsibility to correct errors, oversights and omissions to ensure conformance to the requirements in this document and ASME code requirements.

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5. PREPARATION FOR DELIVERY

5.1 Preservation and Packaging

5.1.1.1 All flex hose assemblies shall be packaged per KSC-C-123. Packing design shall be approved by NASA prior to use.

5.1.1.2 Seal flex hose ends and ports with 10 psig MAWP minimum pressure retaining caps, plugs, or plates equipped with pressure gage and gas charging tee (1 per volume). Male bayonet fittings shall have pressure retaining caps that cover and protect the entire fitting from the end to the flange.

5.1.1.3 All flex hose assembly wetted volumes shall have a dry GN2 blanket pressure of 5 psig +/-2 applied.

5.1.1.4 Annulus shall be sealed and maintained at vacuum levels from acceptance tests.

5.1.1.5 All flex hose assembly vacuum levels shall be checked and recorded prior to shipment for validation at KSC receiving site prior to acceptance.

5.1.1.6 All flex hose assembly purge pressures shall be checked and recorded prior to shipment for validation at KSC receiving site prior to acceptance.

5.2 Packing

The vendor shall package each vacuum jacketed flex hose section within a hard sided container (at a minimum wood construction), using standard commercial practice, ensuring each vacuum jacketed flex hose section is protected against damage during shipment. Shipping containers shall conform to freight classification rules and applicable container specifications.

5.3 Marking for Shipment

6. NOTES

6.1 Intended Use

This document is intended to establish the requirements for fabrication and testing of LO2 Vacuum jacketed flex hoses for Ares Launch Vehicle GSE.

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6.2 Ordering Data

N/A

6.3 Definitions

For the purpose of this document, the following definitions shall apply.

a. **shall:** - Used to indicate a requirement which must be implemented and its implementation verified;

b. **should:** Used to indicate a goal which must be addressed by the design but is not formally verified;

c. **Will:** Used to indicate a statement of fact and is not verified. In some cases the values of quantities included in this requirement have not been determined and are designated as "to be resolved" (TBR), "to be determined" (TBD) or "to be supplied" (TBS).

d. **TBR –** to be resolved / reviewed, involves data / processes to be designed / developed by contractor and provided to NASA at the 45 percent and 90 percent design review for approval

e. **TBD –** to be determined, involves data / processes in work at present by NASA, to be updated by NASA and incorporated to specification prior to contract award.

f. **TBS –** to be supplied, involves data / process to be supplied by the contractor to NASA as part of deliverables of this specification, but are not required for approval by NASA.

NOTICE. The Government drawings, specifications, and/or data are prepared for the official use by, or on behalf of, the United States Government. The Government neither warrants these Government drawings, specifications, or other data, nor assumes any responsibility or obligation, for their use for purposes other than the Government project for which they were prepared and/or provided by the Government, or any activity directly related thereto. The fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded, by implication or otherwise, as licensing in any manner the holder or any other person or corporation nor conveying the right or permission to manufacture, use, or sell any patented invention that may relate thereto.

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